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# Quantization of Atomic and Nuclear Rest Masses

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## 1 Introduction

The review of possible stimulation mechanisms of LENR (low energy nuclear reaction) is presented in [1, 2, 3]. We have concluded that transmutation of nuclei at low energies and excess heat are possible in the framework of the known fundamental physical laws, the universal cooperative resonance synchronization principle [1], and different enhancement mechanisms of reaction processes [2]. The superlow energy of external fields, the excitation and ionization of atoms may play the role of a trigger for LENR. Superlow energy of external fields may stimulate LENR [3]. We give strong arguments that the cooperative resonance synchronization mechanisms are responsible for explanation of how the electron volt world can influence the nuclear mega electron volt world. Nuclear physicists are absolutely sure that this cannot happen. Almost all nuclear experiments were carried out in conditions when colliding particles interacted with the nuclear targets which represented a gas or a solid body. The nuclei of the target are in the neutral atoms surrounded by orbital electrons. All existing experimental data under such conditions teach us that nuclear low energy transmutations are NOT OBSERVED due to the Coulomb barrier. LENR with transmutation of nuclei occurs in different conditions and different processes but these processes have common properties: interacting nuclei are in the ionized atoms or completely without electrons (bare nuclei). Therefore, LENR with bare nuclei and nuclei in ionized atoms demonstrated drastically different properties in comparison with nuclei in neutral atoms [2].

- LENRs take place in open systems in which all frequencies and phases are coordinated according to the universal cooperative resonance synchronization principle. Poor reproducibility of experimental results and extreme difficulties of their interpretation in the framework of modern standard theoretical physics are the main reasons for the persistent non recognition of cold fusion and transmutation phenomena.

Recent progress in both directions is remarkable in spite of being rejected by physical society and this phenomenon is a key point for further success in the corresponding fundamental and applied research. The results of this research field can provide new ecologically pure sources of energy, substances, and technologies. The possibilities of inducing and controlling nuclear reactions at low temperatures and pressures by using different low-energy fields and various physical and chemical processes were discussed in [2, 3]. The aim of this paper is to present the results of phenomenological quantization of atomic and nuclear masses and their differences which can bring new possibilities for inducing and controlling nuclear reactions by atomic processes and new interpretation of self-organizations of the hierarchical systems in the Universe.

## 2 Hydrogen Atom in Classical Mechanics

Is it possible to understand some properties of a hydrogen atom from classical mechanics? The Hamiltonian for a hydrogen atom is

$$H = \frac{m_p \vec{v}_p^2}{2} + \frac{m_e \vec{v}_e^2}{2} - \frac{e^2}{|\vec{r}_p - \vec{r}_e|}. \quad (1)$$

All notations are standard. The definition of the center of mass is

$$m_p \vec{r}_p + m_e \vec{r}_e = 0, \quad (2)$$

and the relative distance between electron and proton is

$$\vec{r} = \vec{r}_p - \vec{r}_e. \quad (3)$$

Equations (1) - (3) lead to the results:

$$\vec{r}_p = \frac{m_e}{m_p + m_e} \vec{r}, \quad \vec{r}_e = -\frac{m_p}{m_p + m_e} \vec{r}, \quad (4)$$

$$H = \frac{\mu \vec{v}^2}{2} - \frac{e^2}{r}, \quad (5)$$

where

$$\mu = \frac{m_p m_e}{m_p + m_e}. \quad (6)$$

The Hamiltonian (5) coincides with the Hamiltonian for the fictitious material point with reduced mass moving in the external field. If we known the trajectory of this fictitious particle then we can reconstruct the trajectories of electron and proton using equations (4):

$$\vec{r}_p(t) = \frac{m_e}{m_p + m_e} \vec{r}(t), \quad \vec{r}_e(t) = -\frac{m_p}{m_p + m_e} \vec{r}(t). \quad (7)$$

It is evident from (7) that the proton and electron move in the opposite directions synchronously.

SO THE MOTIONS OF PROTON, ELECTRON and THEIR RELATIVE MOTION OCCUR WITH EQUAL FREQUENCY

$$\omega_p = \omega_e = \omega_\mu, \quad (8)$$

We can get from (7) that

$$\vec{P}_p = \vec{P}, \quad \vec{P}_e = -\vec{P}, \quad (9)$$

where  $\vec{P}_i = m_i \vec{v}_i$ . If three impulses are equal to each other in absolute value, which means the equality of

$$\lambda_D(p) = \lambda_D(e) = \lambda_D(\mu) = h/P. \quad (10)$$

- Therefore, the motions of proton and electron and their relative motion in the hydrogen atom occur with the same FREQUENCY, IMPULSE (linear momentum) and the de Broglie WAVELENGTH. All motions are synchronized and self-sustained. Therefore, the whole system -hydrogen atom is nondecomposable into independent motions of proton and electron.

We have proved [4] that the same conclusion should be correct for all nuclei and atoms.

### 3 Quantization of Nuclear and Atomic Rest Masses

Almost all quantum mechanical models describe excited states of nuclei, atoms, molecules, condensed matter,... neglecting the structure of the ground state of the investigated systems. Therefore, we have very restricted information about the properties of nuclei, atoms,... in their GROUND STATES. Note that the mutual influence of the nucleon and electron spins (the superfine splitting), the Mossbauer effect,... are well-known. The processes going in the surrounding matter of nuclei change the nuclear moments and interactions of nucleons in nuclei.

- We proved that the motions of proton and electron in the hydrogen atom in the ground state occur with the same frequency; therefore, their motions are synchronized. The co-operation in motion of nucleons in nuclei and electrons in atoms in their ground states is still an open problem. We formulate a very simple and audacious working hypothesis: the nuclear and the corresponding atomic processes must be considered as a unified entirely determined whole process. The nucleons in nuclei and the electrons in atoms form open nondecomposable whole systems in which all frequencies and phases of nucleons and electrons are coordinated according to the universal cooperative resonance synchronization principle.

This hypothesis can be proved at least partly by investigation of the difference between nuclear and atomic rest masses. We performed this analysis for the first time (details in [4]).

The rest mass differences of atoms in the  $\beta$ -decay (single and double) and electron capture (single and double) processes,  $\alpha$ -decay, the differences between nuclear and atomic rest masses are quantized by formula [4] (in  $\frac{MeV}{c^2}$ , experimental data were taken from P. Moller et al., <http://t2.lanl.gov/data/astro/molnix96/massd.html> )

$$\Delta M = 0.0076293945 \cdot \frac{n_1}{n_2}, \quad n_1 = 1, 2, 3, \dots, \quad n_2 = 1, 2, 4, 8. \quad (11)$$

The accuracy of this formula ( up to SEVEN SIGNIFICANT NUMBERS) could be increased if we take into account in our calculations all masses of atoms and nuclei (3177) with up to TEN SIGNIFICANT numbers

$$M = 0.0076293945312 \cdot \frac{n_1}{n_2}, \quad n_1 = 1, 2, 3, \dots, \quad n_2 = 1, 2, 4, 8. \quad (12)$$

Note that this quantization rule is justified for atoms and nuclei with different  $A, N$  and  $Z$ , and the nuclei and atoms represent coherent synchronized systems - a complex of coupled oscillators (resonators). It means that nucleons in nuclei and electrons in atoms contain all necessary information about the structure of other nuclei and atoms. This information is used and reproduced by simple rational relations, according to the fundamental conservation law of energy. Remember that the following relations exist:

$$E = Mc^2 = \hbar\omega, \quad (13)$$

where  $E$  is energy,  $\hbar$  is the Planck constant, and  $\omega$  is frequency. Schrodinger wrote that an interaction between microscopical physical objects is controlled by specific resonance laws. According to these laws, any interaction in a microscopic hierachic wave system a exhibits resonance character

$$\sum_{j=1}^N q_{ij}\omega_j = 0 \quad (14)$$

where  $i = 1, 2, 3, \dots$  is a number of linear independent relations,  $q_{ij}$  is the matrix consisting of only integer numbers. Note that the binary relations from (14) can be rewritten in the following way:

$$\omega_i = \frac{n_j}{n_i} \omega_j, \quad n_i(n_j) = \pm 1, \pm 2, \pm 3, \dots \quad (15)$$

In the classical case the resonance occurs only when the frequency of the external field is close to the proper frequency of the system. The commonly accepted point of view is that the integer numbers in resonance conditions (15) must be small numbers. In the case of the argumental pendulum D.B. Douboshenski and Ya.A. Duboshinsky [5] stable oscillations are maintained by an efficient coupling between subsystems whose frequencies can differ by two or more orders of magnitude. We come to the conclusion that the integer numbers  $n_i$  and  $n_j$  can be any numbers:

$$1 - 10^9.$$

We originated the universal cooperative resonance synchronization principle and this principle is the consequence of the conservation law of energy.

⊗ The cooperative resonance synchronized processes occur in the whole system: cooperative processes including all nucleons and electrons in atoms, in condensed matter and in surrounds when the resonance conditions (15) fulfilled for subsystems and the whole system. In this case, the threshold energy  $Q$  can be drastically decreased by internal energy of the whole system or even more - for example, the electron capture by proton in nuclei can be accompanied by emission of internal binding energy (which is forbidden for the case of the electron capture by free protons) - main source of excess heat phenomenon in LENR. A half-life of neutron in nuclei changes dramatically and depends on the isotopes.

As a final result, the nucleons in nuclei and electrons in atoms have commensurable frequencies and the differences between those frequencies are responsible for creation of beating modes. The phase velocity of standing beating waves can be extremely high; therefore, the nucleons in nuclei and electrons in atoms should get information from each other almost immediately (instantaneously) using phase velocity. Remember that the beating (modulated) modes are responsible for radio and TV-casting.

⊗ The universal cooperative resonance synchronization principle is responsible for the very unity of the nuclei and atoms. The quantization atomic and nuclear masses (12) with the same quanta of mass confirmed our working hypothesis: atoms and nuclei are open systems in which all motions are self-coordinated.

## 4 Conclusion

Note that the quantization rule (11, 12) is justified for atoms and nuclei with different  $A$ ,  $N$  and  $Z$ , and the nuclei and atoms represent coherent synchronized systems - a complex of coupled oscillators (resonators). It means that nucleons in nuclei and electrons in atoms contain all necessary information about the structure of other nuclei and atoms. This information is used and reproduced by simple rational relations, according to the fundamental conservation law of energy-momentum. We originated the universal cooperative resonance synchronization principle and this principle is the consequence of the conservation law of energy-momentum. As a final result, the nucleons in nuclei and electrons in atoms have commensurable frequencies and the differences between those frequencies are responsible for creation of beating modes. The phase velocity of standing beating waves can be extremely high; therefore, all objects of the Universe should get information from each other almost immediately (instantaneously) using

phase velocity [1, 3]. Remember that the beating (modulated) modes are responsible for radio and TV-casting.

Therefore, we came to understand the Mach principle. There are different interpretations of the Mach principle. The Mach principle can be viewed as an entire universe being altered by the changes in a single particle and vice versa.

- *The universal cooperative resonance synchronization principle is responsible for the very unity of the Universe.*

We have shown only a very small part of our calculations by formula (11, 12) and the corresponding comparison with experimental data for atomic and nuclear rest mass differences. This formula produces a surprisingly high accuracy description of the existing experimental data. Our non complete tentative analysis has shown that the quantization of rest mass differences demonstrated very interesting periodical properties in the whole Mendeleev periodic table. We hope that it is possible to create an analog of the Mendeleev periodic table describing atomic and nuclear properties of the atomic and nuclear systems simultaneously.

We have proved [1, 2] the homology of atom, molecule (in living molecules too including DNA) and crystal structures. So inter atomic distances in molecules, crystals and solid-state matter can be written in the following way:

$$d = \frac{n_1}{n_2} \lambda_e, \quad (16)$$

where  $\lambda_e = 0.3324918nm$  is the de Broglie electron wavelength in a hydrogen atom in the ground state ( $\lambda_e = \lambda_p$  in a hydrogen atom in the ground state) and  $n_1(n_2) = 1, 2, 3, \dots$

In 1953 Schwartz [6] proposed considering the nuclear and the corresponding atomic transitions as a unified process. This process contains the  $\beta$ -decay which represents the transition of nucleon from state to state with emission of electron and antineutrino, and simultaneously the transition of atomic shell from the initial state to the final one. A complete and strict solution of this problem is still needed. Magarshak considered recently [7] the resonance approach to formation of atoms and molecules based epn quantum-field interaction.

We did the first step to consider the nuclear and atomic rest masses as unified processes (coupled resonators) which led us to establish the corresponding phenomenological quantization formula (11), and can bring new possibilities for inducing and controlling nuclear reactions by atomic processes and new interpretation of self-organization of the hierachial systems in the Universe including the living cells.

LENR can be stimulated and controlled by the superlow energy external fields. If frequencies of an external field are commensurable with frequencies of nucleon and electron motions, then we should have a resonance enhancement of LENR. Anomalies of LENR in condensed matter (in plasma) and many anomalies in different branches in science and technologies (for example, homoeopathy, influence of music in nature, rhythms, nanostructures...) should be results of cooperative resonance synchronization frequencies of subsystems with open system frequencies, with surrounding and external field frequencies. In these cases threshold energy can be drastically decreased by internal energy of the whole system - the systems are going to change their structures if more stable systems result. Therefore, we have now real possibilities to stimulate and control many anomalous phenomena including low energy nuclear reactions even super-conductivity [1].

We have in principle found a possible way to achieve super-conductivity at room temperature [1].

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